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April 19, 1998

Mr. William B. Johnson
Code 810.0
GSFC/Wallops Flight Facility
Wallops Island, VA 23337

Re: Annual Status Report on Grant NAG5-5084, SwRI Project 15-8087, "Particle Detectors and Data Analysis for Cusp Transient Features Campaign," J. R. Sharber, Principle Investigator

Dear Mr. Johnson:

With this letter I describe the work done under subject grant during the second year of the project, ending April 19, 1998. I will say at the outset that the year included a *very successful* flight campaign from Svalbard, Norway, which was the primary objective of this research. The hard work of all personnel connected with the project has paid off. WFF test and launch personnel, the Norwegian launch team, the PI's and their respective payload science and technical teams, and the collaborating scientists all deserve commendation.

BACKGROUND

Grant NAS5-5084 was awarded to support the participation of SwRI in building the energy per unit charge particle detectors for the Cusp Transient Features Campaign and analysis of flight data from these instruments. The detectors are part of an instrumented payload (Rocket 36.152, Dr. R. Pfaff, P.I.) launched from Svalbard on December 3, 1997, into the dark cusp. The particle instruments, a Cusp Electron Detector (CED) and a Cusp Ion Detector (CID), built on this project, provided differential energy and angular measurements along the rocket trajectory throughout the flight.

ACCOMPLISHMENTS OF PAST YEAR

During the past year the fabrication of the CID and CED instruments was completed; the instruments were calibrated; they underwent T&E testing at WFF; and they were launched from Svalbard, Norway. The fabrication was done at Southwest Research Institute and involved the integration of amplifiers and sensors supplied by GSFC, the high-voltage interface boards supplied by Rutherford Appleton Laboratory, and a correlator board supplied by the University of Sussex. Some photographs of the instrumentation are shown in Figure 1.

FLIGHT OVERVIEW

The "Pfaff payload" (36.152) was launched on December 3 (Day 337), 1997, into the dayside cusp/cleft region at 0906:00 UT. The IMF was weakly southward. The payload reached an apogee of 447 km and appears to have passed over the main dayside precipitation region. A descriptive overview of the particle data follows.

Electrons

When CED high voltage was turned on (at ~ T+110 s) we immediately begin to measure electrons of energies up to a few hundred eV. Several low-energy auroral "arcs" or arc-like structures were seen during the flight starting at about T+122 s. These show up very well in the plot of Figure 2 which shows CED sector 4, one of the 24 CED sensors. The plot is an energy time spectrogram showing differential energy flux (erg/cm^2 s sr eV) vs. time, with altitude, latitude, longitude, and flight time shown below the plot. The times of the enhancements are listed in Table 1. In some cases the time is approximate because of the broadness of the structure. The spectra of the enhancements suggest that the electrons have been accelerated (200 eV or less).

One of our first tasks is to determine is how well these features correspond with the auroral emissions, particularly 4278 A and 5577 A as observed with the ground based photometer observations. This is being pursued with Peter Ning of Boston College/AFL who is providing images of the emissions with the trajectory and a time mark shown on each.

The above enhancements are embedded in a less-structured background of electrons having energies up to a few hundred eV (typically 400 eV). These electrons were detected until approximately T + 600 s at which time the payload altitude was ~170 km. The altitude suggests that the payload passed below the loss height for the few-hundred eV electrons being measured. Thus this probably does not represent a spatial boundary.

Table 1. Electron Intensity Enhancements

ENHANCEMENT	FLIGHT TIME(S)	FEATURE BRACKET TIME(S)*	PEAK ENERGY (eV)**
1	122		
2	143		
		174	
3	178		
		190	
		208	
4	218		200
5	235		
6	248		
7	262		200
		283	
		358	
8	366		
		372	
9	402		
10	416		
11	425		
		506	
12	515		
13	530		
		540	

* The bracketing applies to No. 3, the group 4-7, No. 8, and the group 12-13.
** All energies not shown are less than 200 eV.

Ions

We have background noise on all of the ion sensors. We definitely measure precipitating ions between ~T+ 184 s and T+ 380 s. Ions are probably seen out to about T + 515 -520 s, but after ~ T + 400 s, noise following an ACS firing makes this observation difficult. Starting at about T + 180 s, the ions exhibit some structure, and their spectral peak energy decreases from ~500 eV to ~250 eV (as we flew roughly westward). The spectra were broadly peaked in energy. The structure is suggestive of impulsive entry into the region measured by the Pfaff payload.

A portion of the ion data from CID sector 4 measured between 0910:00 UT and 0911:42 UT (T + 240s to T + 342s) is shown in Figure 3. The top panel is an energy-time spectrogram showing the ion measurements for this time interval. The scale to the right indicates the magnitudes. In general the precipitating ions are most intense in the energy range of several hundred eV, peaking at 300-400 eV near the beginning of this interval and around 200 eV near the end. Also seen in this panel are low-energy (3-10 eV) ions moving upward along the magnetic field lines. (Pitch angles are shown in the second panel.)

The lower panel shows two parameters: (1) energy flux, in units of erg/cm^2 s sr and (2) pitch angle (zero degrees means downcoming). Comparing the two curves shows clearly that the ions between 20 eV and 4 keV are precipitating. The times shown below the lower panel are UT in the top row and flight time in the second row. The energy flux in the second panel is too high because the background noise has not been removed at this writing. The process of removing the noise from the ion sensors has begun and is a task that will continue into the coming year.

First Campaign Data Workshop

Our first campaign workshop was held at GSFC on February 23-24, 1998. It involved the two payload PI's (Pfaff and Maynard) and U. S. participants from SwRI, U. of Maryland, Air Force Research Laboratory, and GSFC as well as Dr. Egeland of the U. of Olso. We went through all rocket and ground-based data associated with the two rocket flights. The Maynard payload (36.153), launched December 2, 1997 (T-0 = 0842:00 UT) and the Pfaff payload (36.152), launched December 3, 1997 (T-0 = 0906:00 UT). J. Sharber attended the meeting and presented the CID and CED data.

PLANS FOR THIRD YEAR

During this year we will prepare for a special cusp session at the Fall AGU and for publication of the scientific results of the campaign.

The second campaign workshop was held at Mission Research Corporation, Nashua, NH June 1-2, 1998. The meeting was hosted by Nelson Maynard. This meeting included both U. S. and foreign collaborators. We examined the flight and ground-based data, improved by the additional reduction and analysis. The second day was devoted to determining (a) which papers should be included in the cusp session at the December AGU meeting and (b) how we approach publication of the data.

Tasks for the CID/CED team include the following:

Data Reduction

(a) Normalizing the CED (electron) data channels. Variations in response are present because of hot spots on the MCP, variations in the geometric factor due to support posts which may partially obscure some sectors, and variation in energy and angular responses. These differences are being measured using the in-flight data by making intercomparisons of sectors at times when pairs of sensors measured electrons of the same pitch angle. This in-flight calibration is made possible by the mis-alignment of the payload axis (from the magnetic field direction) during flight and will provide the normalization factors for each channel. 3-D angular distributions will be produced once the normalizations are complete.

(b) Continuing the noise removal from the CID (ion) data. All the CID channels had a high noise background which persisted to some degree throughout the flight. This may have been environmental although some noise appears to be associated with ACS firings which took place a few seconds before CID high-voltage turn-on and again at about T + 400 s. Unfortunately, the magnitude of count per accumulation interval in a given sensor resulting from the noise varies from sensor to sensor. The fix is a program that reads the raw CID data, determines the average noise level (for each individual sweep), then removes this level from all channels. This program has been tested, is now being modified, and will be ready for general use in the near future.

Data Analysis

Analysis of the flight data will be conducted with the goal of preparing a paper for the Fall 1998 AGU Meeting and a publication as part of a series of papers that show the results of the Svalbard IMF-south flight (The Pfaff flight).

Analysis will include the following:

(a) Providing a thorough description of the particle environment along the rocket trajectory in order to be able to determine which auroral/magnetospheric "region" the payload was in at all times during the flight.

(b) Combining our knowledge of the low-energy particle observations with the measurements of high-energy particles, electric fields, waves, and optical emissions.

(c) Determining the emission rates and electron density profiles using the electron spectra as inputs to a modeling code. The spectra will be taken both in and between selected electron intensity enhancements.

(d) Determining the intensities and energies of the ions at the top of the atmosphere. This is a modeling task that was not in our original proposal and may require additional funding.

(e) A small amount of the grant money will be used for travel to AGU in December.

Any questions regarding this report may be directed to me at 210-522-3853 or via email at sharb@swri.edu.

Very sincerely,

J. R. Sharber

James R. Sharber, P.I.
Department of Space Science

:gfw

cc: Dr. Mary Mellott, NASA/HQ
Dr. Rob Phaff, NASA/GSFC

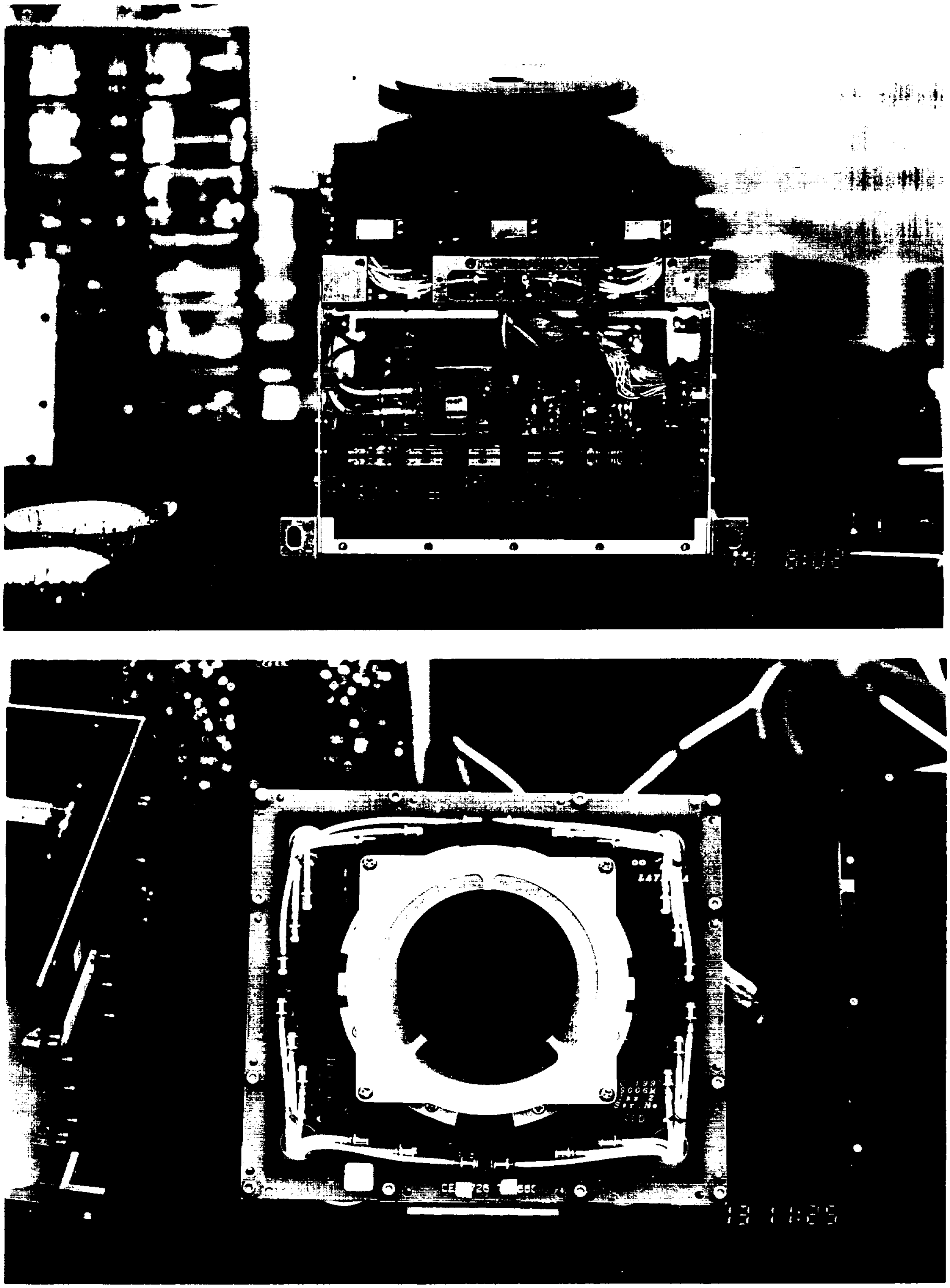

Figure 1. (Top) CED instrument final assembly before delivery for launch. Visible (top to bottom) are the circular collimator, deflection system housing, amplifier board, power supply board, processor board, and correlator board. (Bottom) CED high-voltage interface board showing blackened hemispherical inner delfection plate, copper screen grid (located just above the microchannel plate, not visible), signal capacitors, and signal leads from the 24 angular sectors.

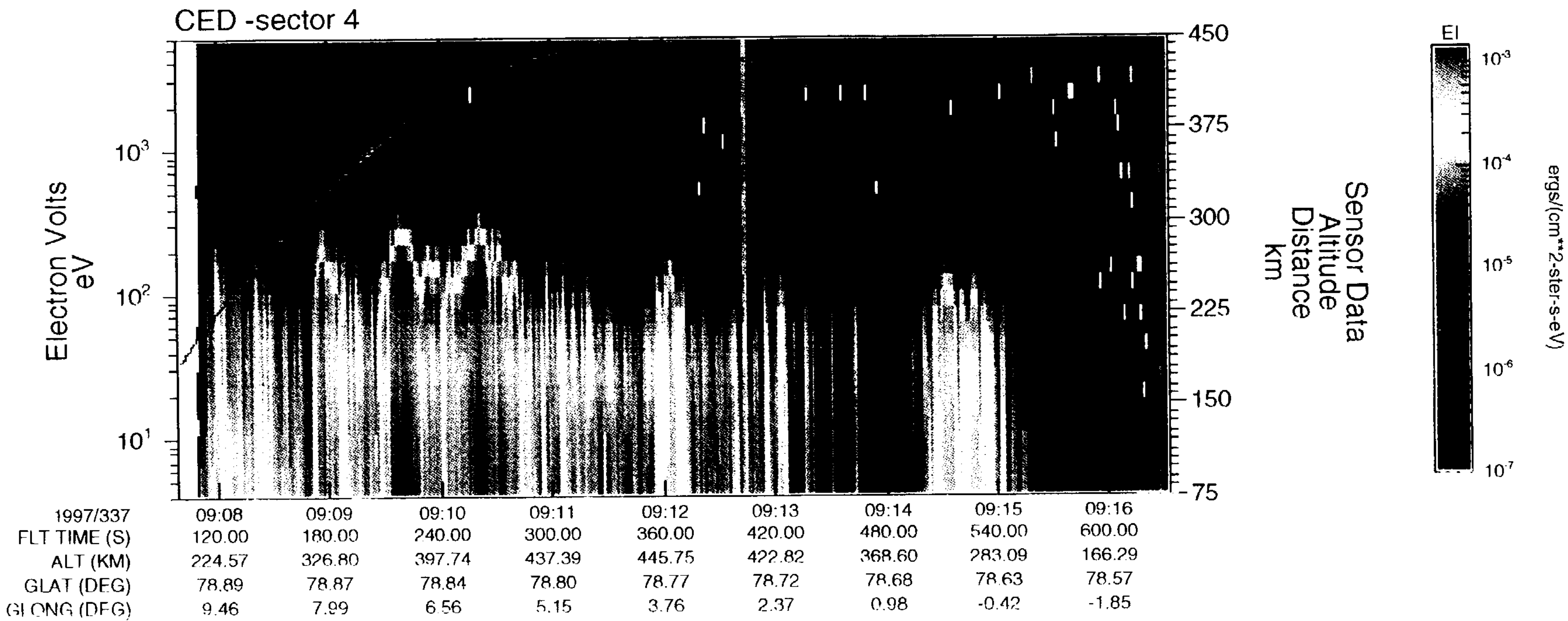

Figure 2. Cusp Electron Detector (CED) energy-time spectrogram showing differential energy flux (erg/cm^2 s sr eV) vs. time, with altitude, latitude, longitude, and flight time shown below the plot. This is one of the 24 angular sectors of the electron data. CED high-voltage turn-on occurred at T+110 s (204 km altitude). Electrons of energy less than a few hundred eV were observed as the payload passed over a portion of the dayside auroral region. On the down-leg precipitating fluxes were not detected after the payload passed below ~170 km. Altitude is also shown on the plot.

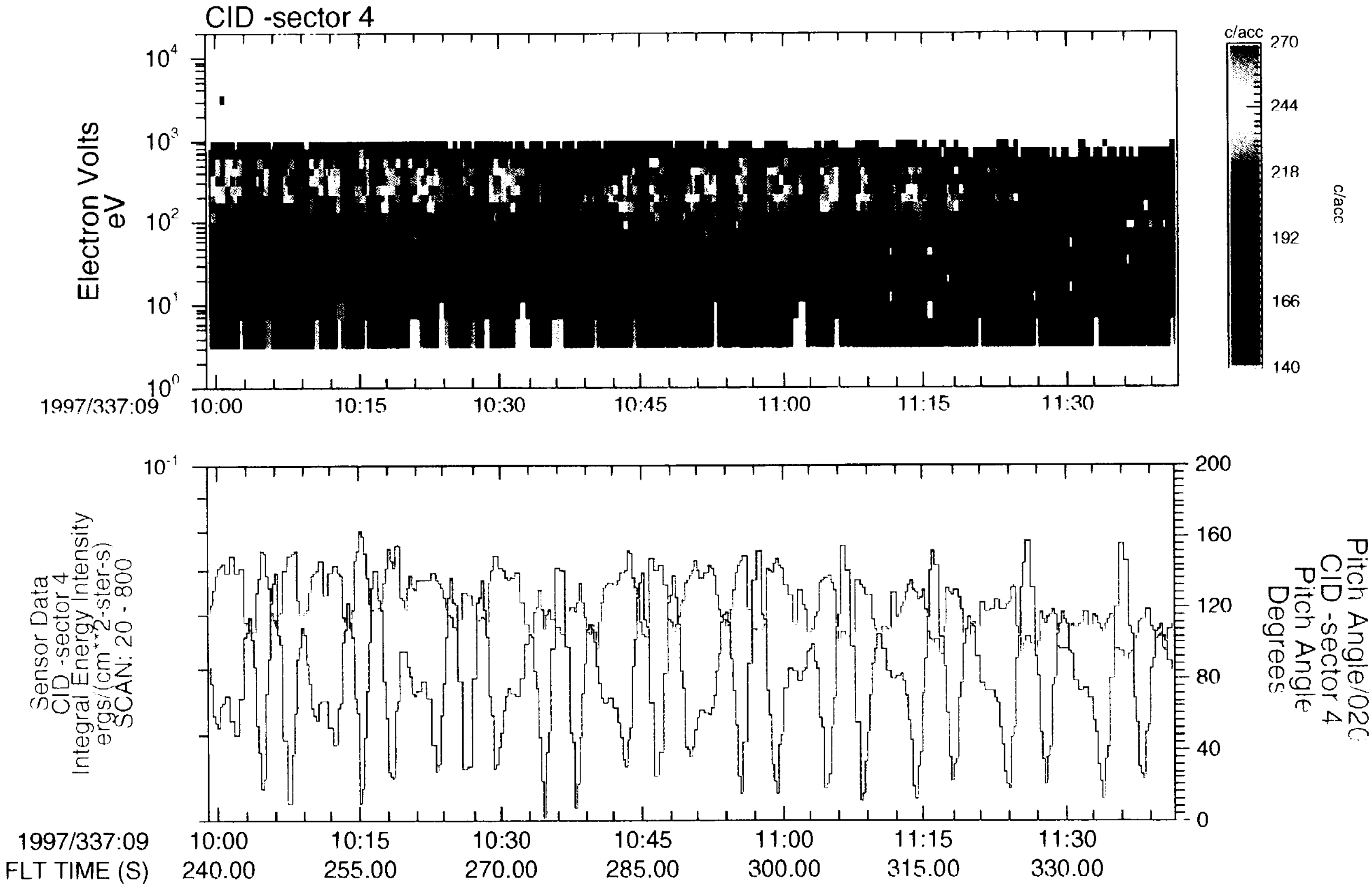

Figure 3. Cusp Ion Detector (CID) spectrogram (top panel) showing measurements between 0910:00 U T and 0911:42 UT (T P240s to t +342s). The spectra peak at 300-400 eV near the beginning of this interval and at about 200 eV near the end. The lower panel shows two parameters integrated energy flux, in units of erg/cm2 s sr and pitch angle (zero degrees means downcoming). Comparing the two curves shows that at these altitudes the ions above about 20 eV are downcoming.